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(54) **CRANKCASE VENTILATION FOR TURBOCHARGED ENGINE**

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F02B 25/06	(2006.01)
F01M 13/02	(2006.01)
F01M 13/00	(2006.01)
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CPC ***F01M 13/02*** (2013.01); ***F01M 13/00*** (2013.01); ***F01M 13/0011*** (2013.01); *F01M 2013/027* (2013.01); *F02M 25/06* (2013.01)

(58) **Field of Classification Search**

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USPC 123/344, 572–574, 41.86, 396, 568.11

See application file for complete search history.

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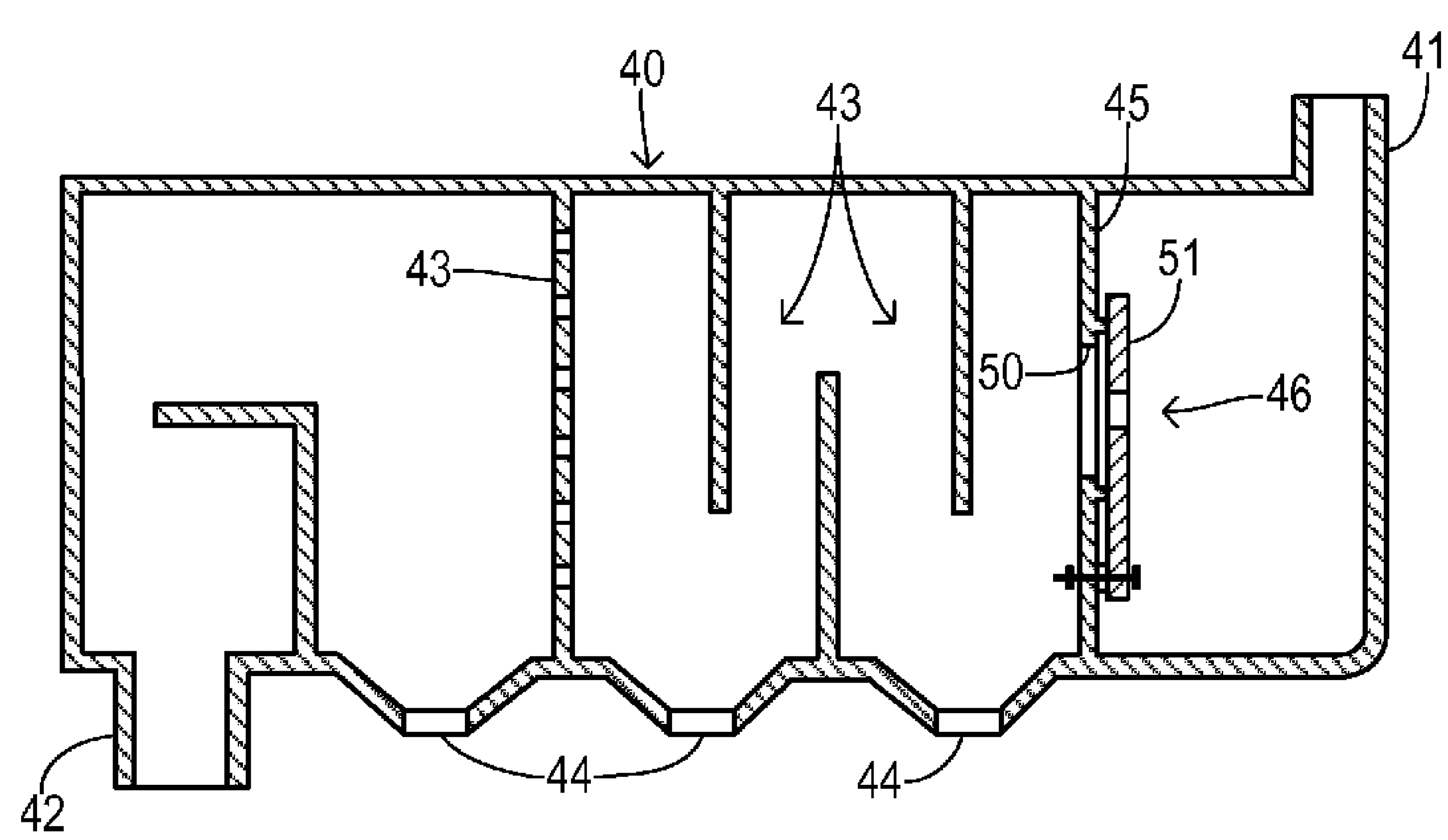
(57) **ABSTRACT**

An internal combustion engine for an automotive vehicle has an intake manifold receiving fresh air via an inlet duct. The engine includes a crankcase. A turbocharger is provided having a compressor with an inlet coupled to the inlet duct and an outlet coupled to the intake manifold. A first vent line couples the crankcase with the compressor inlet. A second vent line couples the crankcase with the compressor outlet and intake manifold. The second vent line has a valve blocking air flow into the crankcase and allowing air flow out from the crankcase. The first vent line comprises a dual-acting valve having a first flow capacity into the crankcase and a second flow capacity out from the crankcase which is greater than the first flow capacity. Thus, crankcase ventilation is optimized for both engine idle and high engine load conditions.

6 Claims, 3 Drawing Sheets



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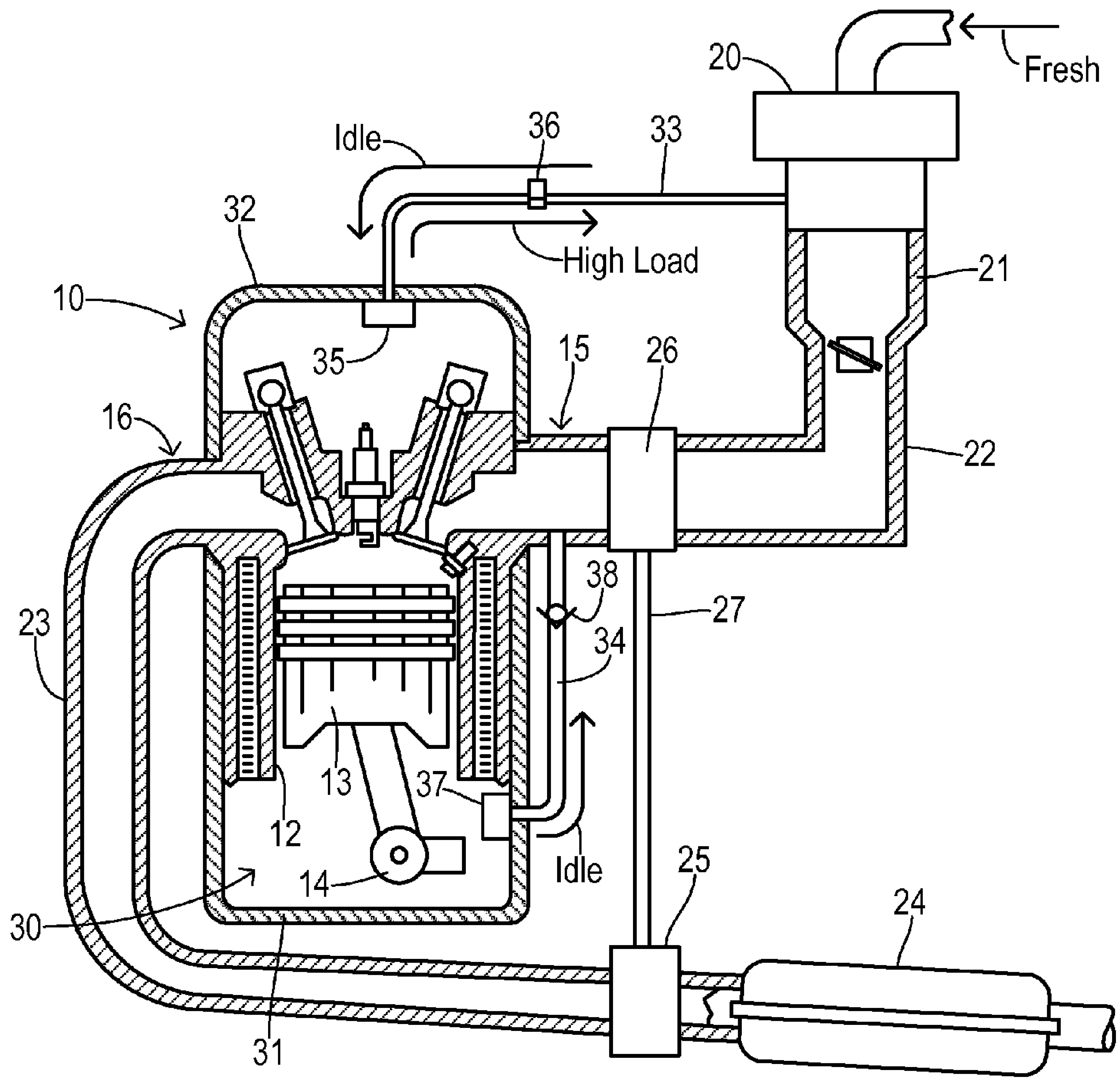

Fig. 1 (Prior Art)

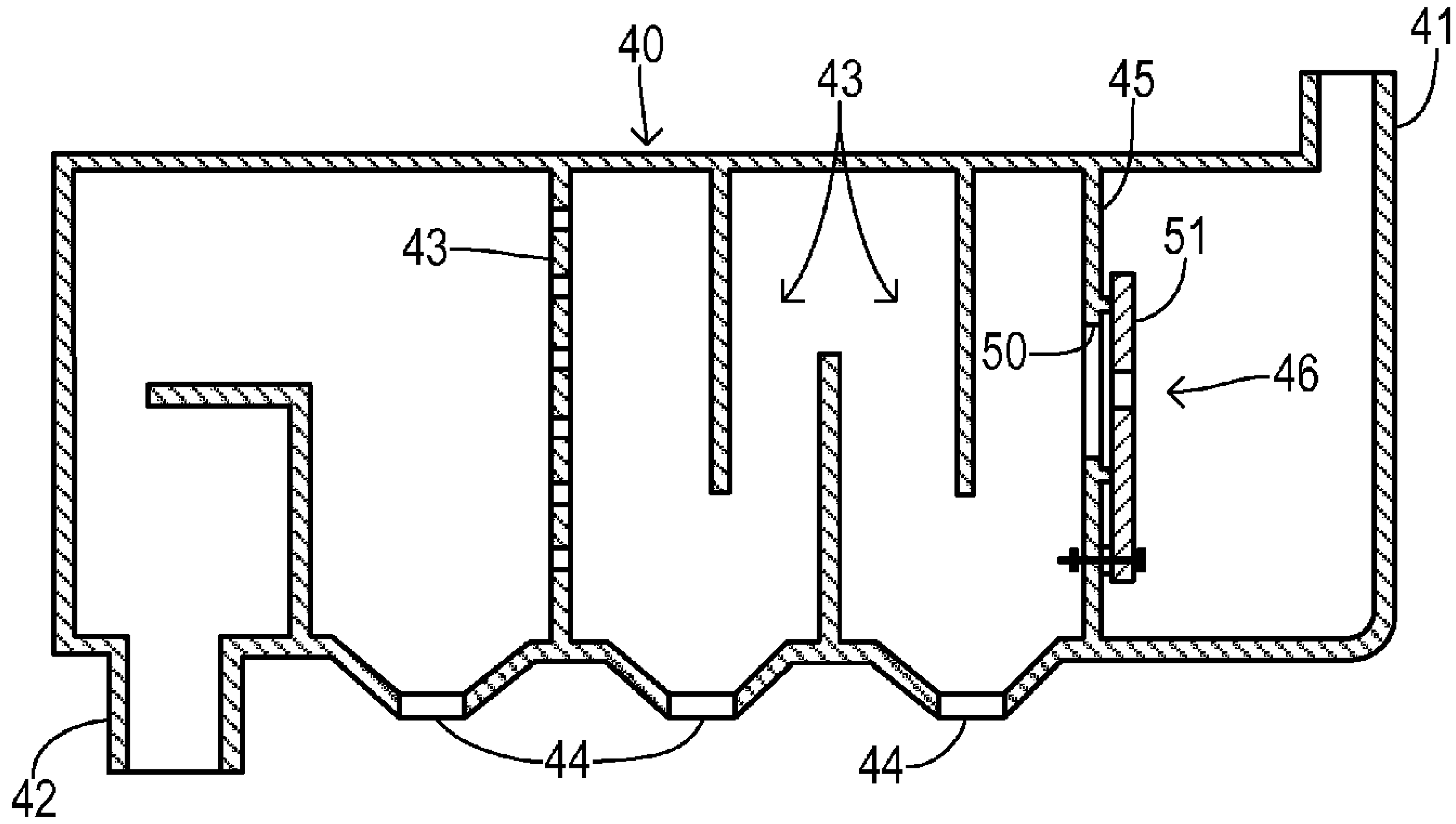

Fig. 2

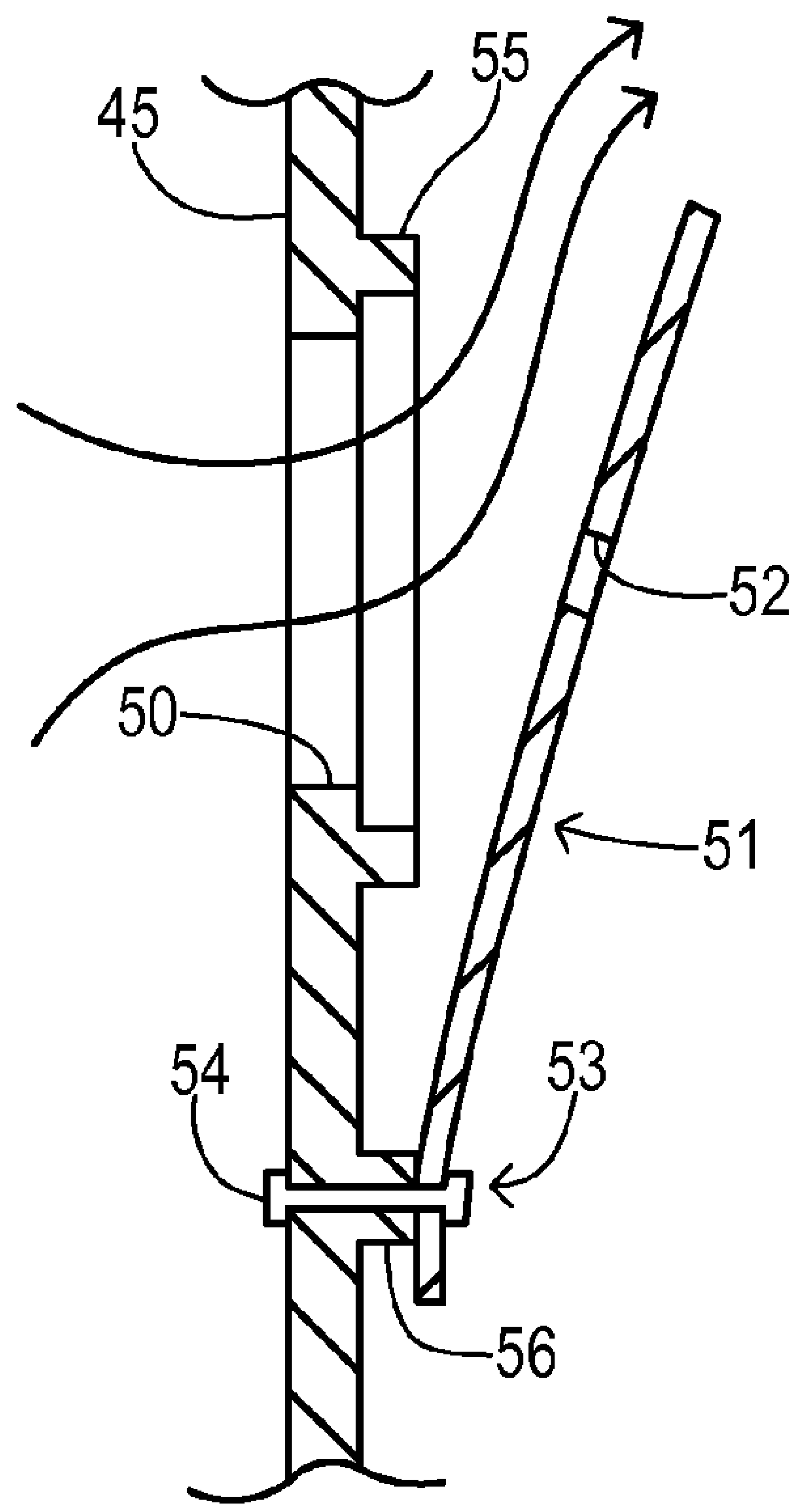

Fig. 3

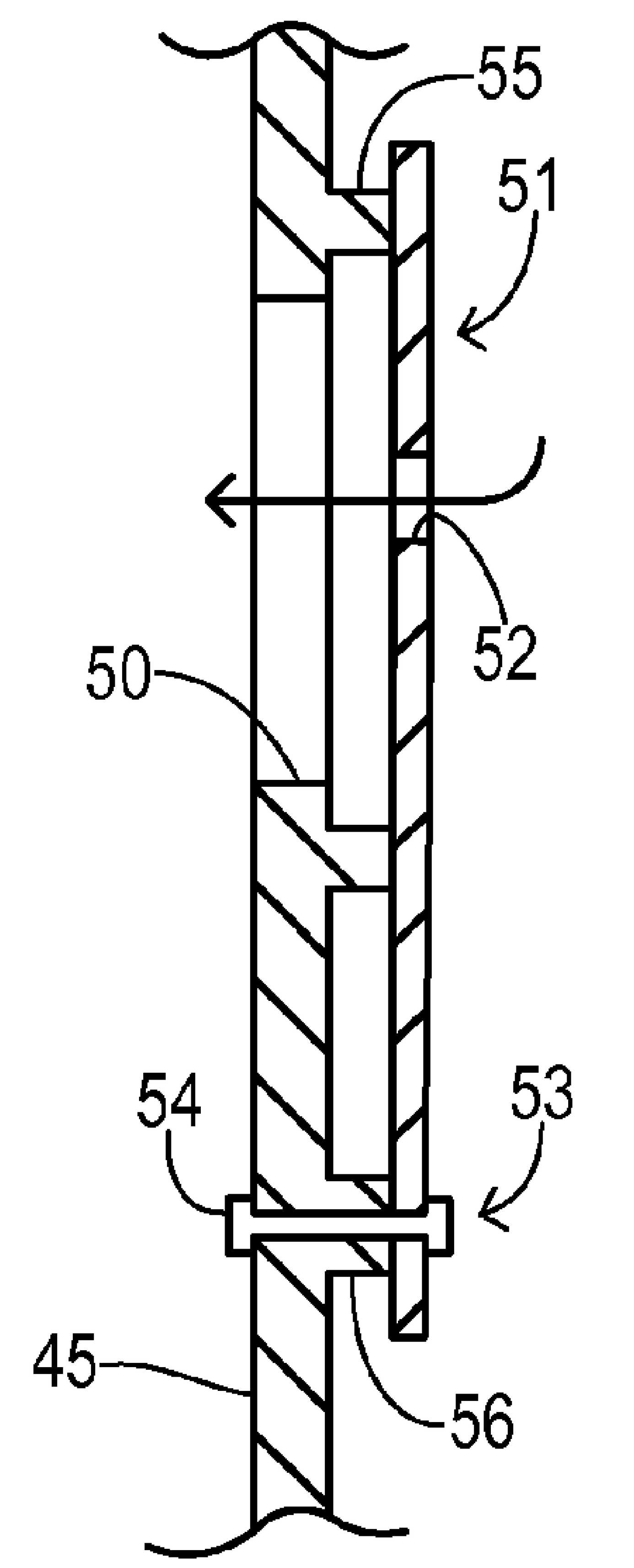

Fig. 4

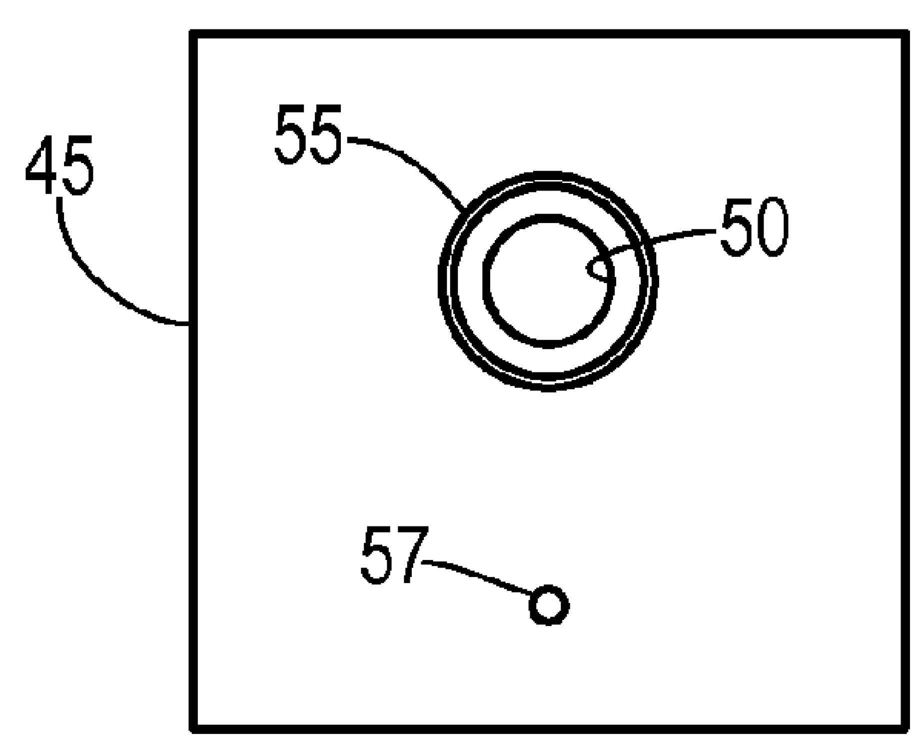

Fig. 5

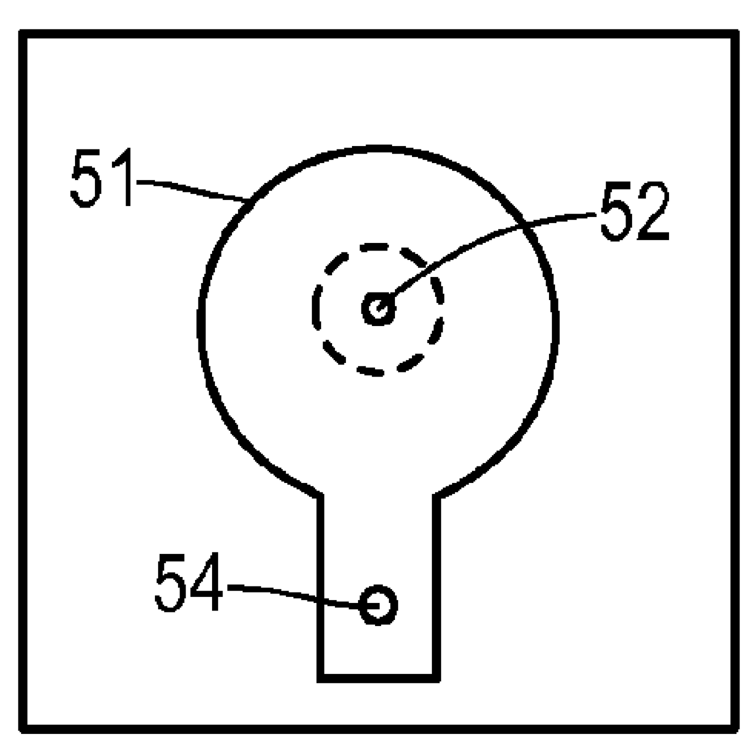

Fig. 6

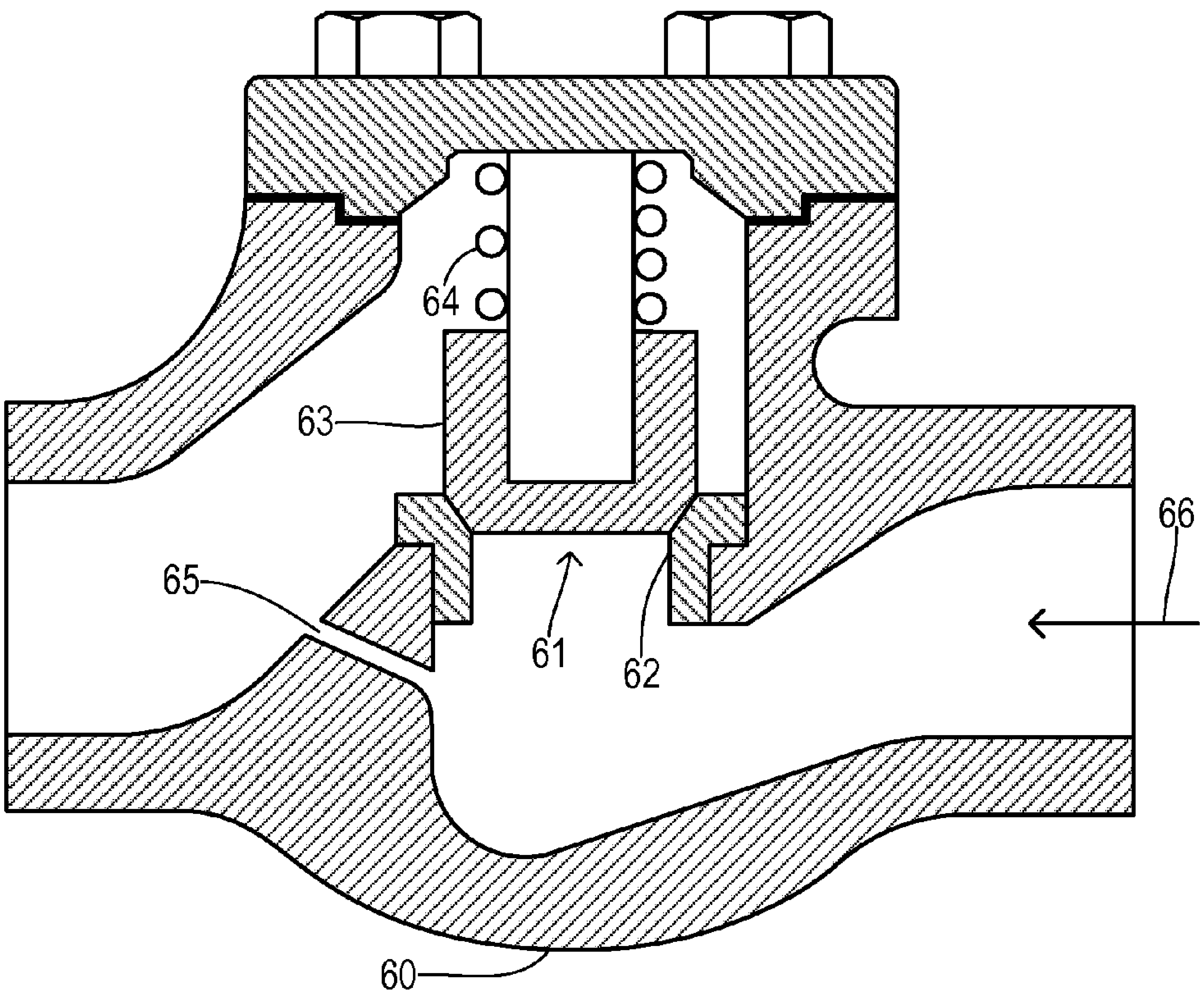

Fig. 7

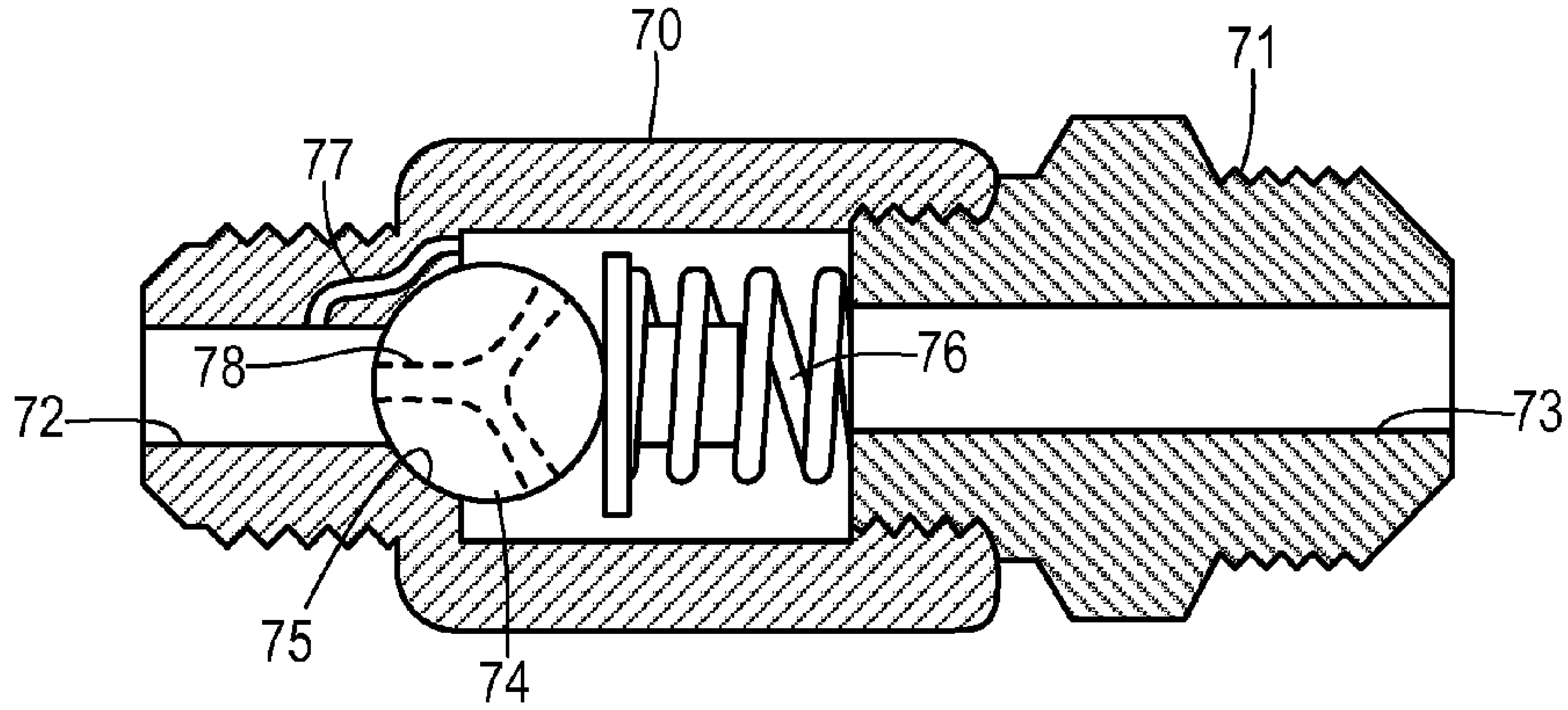

Fig. 8

CRANKCASE VENTILATION FOR TURBOCHARGED ENGINE

CROSS REFERENCE TO RELATED APPLICATIONS

Not Applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

Not Applicable.

BACKGROUND OF THE INVENTION

The present invention relates in general to crankcase ventilation for internal combustion engines, and, more specifically, to a dual-acting valve for crankcase is ventilation of a gasoline engine that employs a turbocharger for compressing the intake air at high engine loads.

Gases accumulate in an engine crankcase when gases from engine cylinders bypass engine pistons and enter the crankcase during engine rotation. These gases are commonly referred to as blowby gases. The blowby gases can be combusted within engine cylinders to reduce engine hydrocarbon emissions using a positive crankcase ventilation (PCV) system which returns the blowby gases to the engine air intake and combusting the gases with a fresh air-fuel mixture. Combusting crankcase gases via the engine cylinders may require a motive force to move the crankcase gases from the engine crankcase to the engine air intake. One conventional way to provide motive force to move crankcase gases into the engine cylinders is to provide a conduit between the crankcase and a low pressure region (e.g., vacuum) of the engine intake manifold downstream of an engine throttle body. In addition, fresh air from a point upstream of the throttle body is added to the crankcase via a separate conduit (i.e., breather) to help flush the blowby products from the crankcase and into the intake manifold.

Use of turbocharging with combustion engines is becoming increasingly prevalent. In an exhaust-gas turbocharger, for example, a compressor and a turbine are arranged on the same shaft (called a charger shaft) wherein a hot exhaust-gas flow supplied to the turbine expands within the turbine to release energy and cause the charger shaft to rotate. The charger shaft drives a compressor which is likewise arranged on the charger shaft. The compressor is connected in an air inlet duct between an air induction and filtering system and the engine intake manifold so that when the turbocharger is activated, the charge air supplied to the intake manifold and engine cylinders is compressed.

Turbocharging increases the power of the internal combustion engine because a greater air mass is supplied to each cylinder. The fuel mass and the mean effective pressure are increased, thus improving volumetric power output. Accordingly, the engine displacement used for any particular vehicle can be downsized in order to operate with increased efficiency and reduced fuel use, wherein the turbocharger is inactive during times of low power requirements and is activated during times of high load, such as wide open throttle (WOT). In addition to reduced fuel consumption, turbocharging has a beneficial effect of reducing emissions of carbon dioxide and pollutants.

Due to the increased pressure at the intake manifold during high load operation which results from compressing the inlet air by the turbocharger compressor, modifications to the conventional crankcase ventilation system are necessary. In particular, the high pressure introduced downstream of the compressor (e.g., in the intake manifold) could reverse the flow in the vent line thereby pressurizing the crankcase to an extent that could cause failure of the seals. To prevent such a reversal, a check valve is usually placed in that vent line. To avoid a buildup of blowby gas in the crankcase, the flow is allowed to reverse in the other vent line (i.e., the breather that otherwise supplies fresh air from a point upstream of the throttle body and turbocharger compressor into the crankcase). Thus, any pressure buildup in the crankcase that could damage the seals is prevented.

During engine idling when a large vacuum is present at the intake manifold, it is desirable to maintain a negative pressure in the crankcase so that blowby gases are readily captured and removed. To ensure a negative crankcase pressure at idle on a boosted gas (i.e., turbocharged) engine, it is often necessary to restrict the fresh air feed to the crankcase. An appropriately sized restriction in the corresponding breather vent line is used to accomplish this. However, if the crankcase fresh air feed is restricted too much then the crankcase may become positively pressurized under full load conditions (i.e., when the restricted vent line or breather reverses flow to evacuate the blowby gases into the low pressure section of the air inlet system), which can jeopardize the crankcase sealing integrity. It is often difficult or impossible to find a restriction level that provides the needed vacuum at idle while not creating an undesirably large positive pressure during full load operation.

SUMMARY OF THE INVENTION

The present invention solves the foregoing problem using an active valve with a dual flow rate orifice. A small orifice provides a smaller flow capacity at idle to ensure the necessary crankcase vacuum. Under full load, the device transitions to a larger orifice to allow a higher flow capacity to prevent crankcase pressurization. One embodiment of such a device uses a spring-steel metal flap valve with a small hole in the center. During idle when fresh air is flowing through the device into the crankcase, the metal flap is pulled shut against a larger orifice in a valve body in the form of a sealing wall (which can be part of an oil separator housing, for example). In this position, the flow into the crankcase is controlled by the small hole in the center of the metal flap. Under full load when the flow direction reverses and blowby is flowing out of the crankcase, the metal flap valve is pushed open exposing the larger orifice under the metal flap. The larger orifice allow sufficient flow to prevent pressurization of the crankcase under full load. The device could be incorporated anywhere in the PCV system, such as directly integrated into the oil separator in the cam cover. It could also be incorporated into one of the PCV hoses or quick connectors in the PCV system. Other embodiments may include elastomeric check valves with holes directly in the check valve or small holes or passages that bypass the check valve when in the closed position.

In one aspect of the invention, a vehicle comprises an internal combustion engine with an intake manifold receiving fresh air via an inlet duct. The engine includes a crankcase. A turbocharger is provided having a compressor with an inlet coupled to the inlet duct and an outlet coupled to the intake manifold. A first vent line couples the crankcase with the compressor inlet. A second vent line couples the crankcase with the compressor outlet and intake manifold. The second vent line has a valve blocking air flow into the crankcase and allowing air flow out from the crankcase. The first vent line comprises a dual-acting valve having a first flow capacity into the crankcase and a second flow capacity out from the crankcase which is greater than the first flow capacity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a turbocharged internal combustion engine with a conventional crankcase ventilation arrangement.

FIG. **2** is a cross-sectional view of an oil separator incorporating a dual-active valve of the present invention.

FIGS. **3** and **4** are cross-sectional views showing two positions of the valve of FIG. **2**.

FIG. **5** is a plan view of a seating wall according to one embodiment of the valve of the invention.

FIG. **6** is a plan view showing a flat spring member mounted to the seating wall of FIG. **5**.

FIG. **7** is a cross-sectional view of a modified check valve used in alternative embodiment of the invention.

FIG. **8** is a cross-sectional view of another modified check valve used in another alternative embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. **1**, an internal combustion engine **10** in an automotive vehicle includes a plurality of cylinders. One cylinder is shown, which includes a combustion chamber **11** and cylinder walls **12** with piston **13** positioned therein and connected to crankshaft **14**. Combustion chamber **11** communicates with an intake manifold **15** and exhaust manifold **16** via respective intake and exhaust valves operated by respective cams.

Engine **10** may preferably utilize direct fuel injection and an electronic distributorless ignition system as known in the art. Fresh outside air is conducted to engine **10** via an air filter **20**, a throttle body **21**, and an air inlet duct **22** connected to intake manifold **15**. Combustion products exiting exhaust manifold **16** are conducted via a conduit **23** to a catalytic converter **24** on their way to an exhaust system (not shown). A turbocharging system is comprised of a turbine **25** positioned in the exhaust gas flow before catalytic converter **24** and coupled to a compressor **26** by a driveshaft **27**. Exhaust gases passing through turbine **25** drive a rotor assembly which in turn rotates driveshaft **27**. In turn, driveshaft **27** rotates an impeller included in compressor **26** thereby increasing the density of the air delivered to combustion chamber **11**. In this way, the power output of the engine may be increased. One or more bypass valves (such as a wastegate) may be provided for turbine **25** and/or compressor **26** that are controlled in a desired manner to activate or deactivate turbocharging according to engine loading.

Crankcase **30** refers to a crankcase volume that may be defined in part by an oil pan **31** and a cam cover **32**, for example. When an air-fuel mixture is combusted in engine combustion chamber **11**, a small portion of combusted gas may enter crankcase **30** through the piston rings. This gas is referred to as blowby gas. To prevent this untreated gas from being directly vented into the atmosphere, a positive crankcase ventilation (PCV) system is utilized which includes a first vent line (breather) **33** and a second vent line **34**. First vent line **33** is coupled between cam cover **32** and the low pressure side of compressor **26** such as at throttle body **21** (or alternatively at any other position along air inlet duct **22**). Second vent line **34** is connected to crankcase **30** near oil pan **31** and to the high pressure side of compressor **26** (e.g., to intake manifold **15**). Oil separators **35** and **37** are preferably included at the connections of vent lines **33** and **34** to crankcase **30** to remove entrained oil from any gasses being returned to the engine air intake.

During engine idling and low load conditions when turbocharger compressor **26** is not activated, a vacuum pressure in intake manifold **15** causes a crankcase ventilation flow in which fresh air enters crankcase **30** via first vent line **33** and leaves crankcase **30** via second vent line **34**. A one-way check valve **38** in second vent line **34** allows flow in this direction. A restriction **36** in first vent line **33** has a size (i.e., flow capacity) that limits the amount of fresh air allowed to enter crankcase **30**. When compressor **26** is activated during a high load condition such as wide-open throttle, pressure in intake manifold **15** increases to a pressure higher than the pressure in crankcase **30**. Reverse flow in second vent line **34** is blocked by check valve **38**. Excessive accumulation of blowby gas in crankcase **30** is avoided by allowing a reverse flow in first vent line **33**. The sizing of restriction **36** has been a tradeoff between the desire to have a sufficiently small flow capacity during idle to maintain a desirable negative pressure in crankcase **30** (which would be lost if an unlimited amount of fresh air could enter via first vent line **33**) and a desire to have a sufficiently large flow capacity during high engine load so that a high pressure buildup in crankcase **30** is avoided.

FIGS. **2**-**4** show a first embodiment of the invention for employing a dual-acting valve having a flow capacity which varies depending upon the direction of air flow in order to simultaneously obtain optimized performance for limiting the inflow of fresh air during engine idling and fully venting blowby gas during high engine load. An air oil separator **40**, which may be integrated with a cam cover, includes an inlet **41**, an outlet **42**, and plurality of internal baffles **43** which collect oil and return it to the crankcase via drains **44**. A sealing wall **45** partitions oil separator **40** into two separate chambers which are selectably coupled by dual-acting valve **46**. Valve **46** includes a large opening **50** in sealing wall **45** which is configured to provide a large flow capacity during blowby flow from the crankcase. A movable flap **51** is arranged to cover opening **50** and has a smaller orifice **52** aligned with opening **50** configured to provide a smaller flow capacity for fresh air flowing in the direction into the crankcase. Movable flap **51** is coupled at a pivot point **53** to sealing wall **45** by a fastening pin **54**. Movable flap **51** may preferably be comprised of a flat spring formed of sheet metal or other material that naturally returns to a flat configuration against opening **50** as shown in FIG. **4**. To improve the seating of flap **51** on sealing wall **45**, a raised sealing rib **55** is preferably disposed concentrically around opening **50** to bear against flap **51** when in the closed position. A boss **56** is preferably provided at pivot point **53** to align flap **51** with the outer edge of rib **55**. As shown in FIG. **3**, when the flow direction reverses through valve **46** in order to vent the crankcase during turbocharger activation, the flowing gas deflects flap **51** away from is sealing wall **45** so that opening **50** is unblocked, thereby obtaining the higher flow capacity desired for venting the blowby gases.

FIG. **5** shows a plan view of sealing wall **45** with aperture opening **50** surrounded by raised sealing rib **55**. A mounting hole **57** is provided for attaching a flat sheet-metal spring for forming movable flap **51** has shown in FIG. **6** using fastening pin **54** so that orifice **52** in flap **51** is aligned with opening **50**.

A valve using a movable flap is particularly adapted for use in an oil separator. The dual-acting valve may also be located in other structures of the PCV system, such as being integrated with a vent line connector or inserted as a separate device in a vent line. Various types of check valves may be employed such as the valve shown in FIG. **7** wherein a valve body **60** includes an opening **61** with a valve seat **62** for receiving a plunger **63** which is normally disposed against seat **62** by a spring **64**. A bypass passage **65** bypasses the valve seat for providing the first flow capacity into the crankcase. During reverse flow indicated by arrow **66**, plunger **63** is lifted off from valve seat **62** to provide a second flow capacity out from the crankcase which is greater than the first flow capacity. Valve body **60** is adaptable for use as a separate device connected in a PCV line or as an integral device formed with a connector, for example.

FIG. **8** shows another embodiment wherein a valve body is comprised of a housing **70** and a threaded plug **71** with internal passages **72** and **73**, respectively. A check ball **74** lodged in passage **72** is normally disposed against a valve seat **75** by a spring **76**. A bypass passage **77** in housing **70** may be configured to provide a first flow capacity into the crankcase. Alternatively, check ball **74** may include bypass passages **78**. Check ball **74** is movable to the right against spring **76** in order to allow a reverse flow from the crankcase into passage **72** and out from passage **73**, thereby providing a second flow capacity for venting blowby gas which is greater than the first flow capacity.

What is claimed is:

1. A vehicle comprising: an internal combustion engine with an intake manifold receiving fresh air via an inlet duct, wherein the engine includes a crankcase; an oil separator associated with the crankcase; a turbocharger having a compressor with an inlet coupled to the inlet duct and an outlet coupled to the intake manifold; a first vent line coupling the crankcase with the compressor inlet; and a second vent line coupling the crankcase with the compressor outlet and intake manifold, the second vent line having a valve blocking air flow into the crankcase and allowing air flow out from the crankcase; wherein the first vent line comprises a dual-acting valve having a first flow capacity into the crankcase and a second flow capacity out from the crankcase which is greater than the first flow capacity, wherein the dual-acting valve comprises: a seating wall having an opening configured to provide the second flow capacity, wherein the seating wall is comprised of a partitioning wall within an oil separator; and a movable flap for covering the opening and having an orifice aligned with the opening configured to provide the first flow capacity, wherein the movable flap is seated against the seating wall when fresh air flows through the first vent line into the crankcase, and wherein the movable flap is deflected away from the seating wall when blowby gas from the engine flows through the first vent line out from the crankcase.

2. The vehicle of claim **1** wherein the movable flap is comprised of a flat spring attached to the seating wall and normally closed against the opening on a side of the seating wall remote from the crankcase so that a flow of blowby gas from the crankcase through the first vent line when the turbocharger is active deflects the flat spring off the seating wall to unblock the opening.

3. The vehicle of claim **2** wherein the seating wall includes a raised sealing rib disposed concentrically around the opening to bear against the flat spring when the flat spring is in a closed position.

4. A ventilation system for a crankcase of a combustion engine with a turbocharger, wherein the engine comprises an oil separator associated with the crankcase, the ventilation system comprising: a vent line coupling the crankcase to a low pressure side of the turbocharger; and a valve in the vent line having a first capacity into the crankcase to supply fresh air during engine idling and having a second capacity greater than the first capacity out from the crankcase to vent engine blowby during operation of the turbocharger, wherein the valve comprises: a seating wall having an opening configured to provide the second capacity, wherein the seating wall is comprised of a partitioning wall within the oil separator; and a movable flap for covering the opening and having an orifice aligned with the opening configured to provide the first capacity, wherein the movable flap is seated against the seating wall when fresh air flows through the vent line into the crankcase, and wherein the movable flap is deflected away from the seating wall when the blowby from the engine flows through the vent line out from the crankcase.

5. The ventilation system of claim **4** wherein the movable flap is comprised of a flat spring attached to the seating wall and normally closed against the opening on a side of the seating wall remote from the crankcase so that a blowby flow from the crankcase through the vent line when the turbocharger is active deflects the flat spring off the seating wall to unblock the opening.

6. The ventilation system of claim **5** wherein the seating wall includes a raised sealing rib disposed concentrically around the opening to bear against the flat spring when the flat spring is in a closed position.

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